



Московский государственный технический университет
имени Н.Э. Баумана

Учебно-методическое пособие

И.А. Набатова

**Обучение чтению литературы
на английском языке
по специальности «Робототехника»**

Издательство МГТУ им. Н.Э. Баумана

МОСКОВСКИЙ ГОСУДАРСТВЕННЫЙ ТЕХНИЧЕСКИЙ
УНИВЕРСИТЕТ имени Н.Э. БАУМАНА

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В пособие вошли оригинальные тексты из современной научно-технической литературы на английском языке, тематически связанные между собой и посвященные последним достижениям робототехники в области космических исследований. В каждый раздел пособия включены задания и упражнения для освоения грамматических и лексических трудностей, развития навыков перевода с английского языка на русский и навыков устной речи для ведения беседы по специальности.

Для студентов старших курсов, обучающихся по специальности «Робототехника».

Предисловие

Настоящее учебно-методическое пособие предназначено для обучения чтению научно-технической литературы по специальности «Робототехника». Пособие состоит из трех разделов, каждый из которых содержит два или три текста, словарный блок, задания и упражнения.

Тексты А предназначены для изучающего чтения и перевода; перед ними помещены словарный блок и предтекстовые упражнения на перевод терминологических и глагольных словосочетаний и отработку грамматических и лексических трудностей.

Тексты В и С могут использоваться как для изучающего, так и для ознакомительного и поискового чтения.

Послетекстовые упражнения направлены на закрепление грамматического материала, усвоение лексики и смыслового содержания текста, на развитие навыков устной речи (перефразирование, перевод с русского), аннотирования и на освоение правил словообразования. Кроме упражнений в пособие также включены задания по практике речи, как монологической, так и диалогической. Большое количество разнообразных упражнений дает преподавателю возможность их выбора в зависимости от уровня и интересов учащихся.

Пособие может использоваться как для самостоятельной работы студентов, так и для аудиторной работы под руководством преподавателя.

UNIT 1

I. Word list:

beyond *prep* – сверх, кроме, помимо
blanket *n* – зд. покрытие, защитный слой
boost *v* – зд. выводить, разгонять
cargo bay – грузовой отсек
clamp *n* – зажимное устройство, зажим
closed-circuit TV – внутреннее ТВ (замкнутая система ТВ)
departure *n* – зд. отклонение
deploy *v* – размещать, развертывать, запускать (на орбиту)
dot *n* – точка
drive *v* – приводить в движение, управлять
end effector – рабочий орган
flight deck – кабина экипажа
grapple fixture – зажимное приспособление
grasp *v* – хватать, зажимать
hinge *n* – петля (дверная)
knobby *adj* – выпуклый
once *conj* – как только
operate *v* – работать, управлять
payload *n* – полезная нагрузка
port side – левый борт
pitch joint – сочленение с горизонтальной осью (с возможностью поворота в вертикальной плоскости)
projection *n* – зд. выступ
rather than – а не; вместо
sense *v* – опознавать, воспринимать
separation *n* – зд. интервал, расстояние
slide *v* – скользить
translational *adj* – зд. поступательный
three-wire snare – трехпроводное захватывающее устройство
yaw joint – сочленение с вертикальной осью (с возможностью поворота в горизонтальной плоскости)

II. Translate the following word combinations:

remote manipulator system, space launch system, low-Earth orbit, port side cargo bay door hinges, machine vision system, finger-like clamps, degrees of freedom, rotational and translational hand controllers, rate of rotation, independently operating joints, an improvement on the human arm analog;

to install a robot arm, to transport payloads, to deploy payloads, to handle a task, to drive the joints, to sense joint positions, to work the arm, to determine the distance, to be linked to a computer, to key a task into the computer.

III. Translate the following sentences.

A. Paying attention to the Attributive clause.

1. Although we are surrounded by robots that we think of as automated tools, there are some sophisticated robots already in use.
2. The load the manipulator is able to lift depends on the weight of the robot itself.
3. The switches send “start work” signals to and receive “completion” signals from the interfacing machines the robot is interacting with.
4. The body of a robot is related to the job it must perform.
5. Rehabilitation robots are robots that help permanently or temporarily disabled people with the matters they cannot deal with themselves.

B. Paying attention to the Infinitive.

1. There are many things to be taken into consideration when designing a climbing robot.
2. Now we shall discuss the system of units to be employed later in our discussion.
3. The ultimate in robotic intelligence and sophistication might take on forms yet to be imagined.
4. The advantages to be gained through automation are numerous.

5. There is a great analogy to be found between space robots and those involved in industry.

IV. Read the first part of Text 1A and fill in each gap with the best-fit word from the following list. For each gap you are offered four different options, of which only one is correct.

- | | | | |
|-------------------------------|------------------|--------------------------|---------------------|
| 1) A. transport | B. deploying | C. transporting | D. boosting |
| 2) A. as | B. beyond | C. unless | D. once |
| 3) A. communication | B. defective | C. artificial | D. low-orbit |
| 4) A. have been
installed | B. installed | C. has been
installed | D. has
installed |
| 5) A. having | B. does not have | C. is made of | D. features |
| 6) A. consists of | B. is made of | C. has | D. includes |
| 7) A. driven | B. drive | C. move | D. driving |
| 8) A. through | B. due to | C. because of | D. beyond |
| 9) A. make it
possible for | B. needs | C. operating | D. enables |
| 10) A. to be oriented | B. to reach | C. to move | D. to orient |

V. Read and translate Text 1A

TEXT 1A

SHUTTLE REMOTE MANIPULATOR SYSTEM (RMS)

(I) The Space Shuttle is a space launch system that is designed primarily for _____ 1) large and small payloads to and from low-Earth orbit. In the back of the Orbiter is a cargo bay, large enough to contain one and one-half school buses.

_____ 2) the orbiter is in space, payloads in the bay need to be deployed. Satellites, for example, have to be removed from the bay and boosted to higher orbits.

_____ 3) satellites, already in space, need to be brought back into the bay for repair or return to the Earth. To handle these tasks as well as the assembly of large structures in orbit, a robot arm

_____ 4) along the port side cargo bay door hinges. The arm is called the Remote Manipulator System.

It is a highly sophisticated robotic device that is analogous to the human arm. Fifteen meters long, the RMS _____

5) a shoulder, elbow, wrist, and hand, although the hand does not look at all like a human hand (see Fig. 1). The skeleton of the arm _____6) lightweight graphite composite materials. Covering the skeleton are skin layers consisting of thermal blankets. The muscles _____7) the joints are electric actuators (motors), and built-in sensors, like nerves, sense joint positions and rates of rotation.

_____8) the initial similarities to the human arm, the RMS features additional capabilities. For its needed degrees of freedom (DOF), the RMS has six independently operating joints. In the shoulder is a pitch joint (up or down) and a yaw joint (right or left). The elbow has a pitch joint and the wrist has pitch, yaw, and roll (rotation) joints, an improvement on the human arm. The shoulder joint _____9) the end effector to move to any point along the surface of a sphere. The elbow joint gives the RMS freedom _____10) any point within that sphere and wrist joints permit any desired orientation of the end effector.

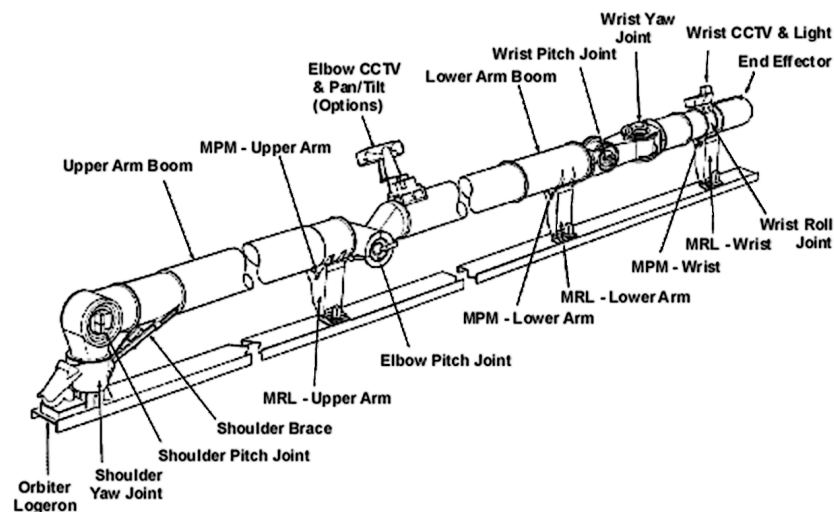


Fig.1. The RMS's mechanical parts:

MPM – Manipulator Positioning Mechanism (установочный механизм манипулятора); MRL – Manipulator Retention Latch (фиксирующий механизм манипулятора); Brace – распорка; Pan/tilt unit – устройство наклона/поворота камеры

(II) Further capabilities of the RMS include two closed-circuit television cameras, one at the wrist and one at the elbow. These cameras enable an astronaut, working the arm from the flight deck of the Orbiter, to see critical points along the arm and the target the arm is moving to. The television camera at the wrist is also linked to a computer to produce a “machine vision” that enables the arm to operate in a fully automatic mode. To accomplish this, the grapple fixture or target on a particular payload will have four white dots. The computer in the machine vision system will sense the separation of the dots and from that determine the distance and direction the end effector is from the target and its rate of motion.

The end effector of the RMS is the most radical departure from the human arm analog. Rather than sporting* finger-like clamps, the end effector has a three-wire snare. On each payload to be grasped by the arm is a grapple fixture. The fixture is a small knobby projection that is mounted to a disc. To grasp the payload, the end effector slides over the fixture and the wires are pulled together in the center in a manner similar to the closing of a diaphragm on camera. Once tightly held by the wires, the disc is pulled into the effector and the payload is ready to be deployed.

Operation of the RMS can be accomplished in several modes ranging from fully manual to fully automatic. In manual mode, an astronaut controls the arm with rotational and translational hand controllers. These devices look similar to controllers on home video games. While watching the arm through the windows looking out into the cargo bay, and on closed circuit television, the astronaut can move the end effector with ease. In the automatic mode, the task to be accomplished is keyed into the computer and the RMS performs its task.

* to sport – зд. щеголять (*разг.*).

VI. Answer the questions.

1. What tasks can the RMS perform?
2. How big is the cargo bay of the Orbiter?
3. What is usually done with defective satellites?
4. What is the RMS made of?
5. If we compare the RMS with a human arm, what parts of it correspond to the human muscles and nerves?
6. How many joints does the RMS have?
7. What does the abbreviation 'DOF' stand for?
8. How many DOF are needed for the RMS to perform its tasks?
9. What are the possible modes of RMS operation?
10. How does the RMS "see" the target to be grasped while operating in the automatic mode?
11. What devices does an astronaut use to operate the RMS in the manual mode?

VII. Match the words on the right and on the left to make word combinations. Translate:

- | | |
|------------------|--------------------------------|
| 1) to reach | a) a task |
| 2) to deploy | b) large structures in orbit |
| 3) to boost | c) a robot arm |
| 4) to bring back | d) the joints |
| 5) to handle | e) payloads |
| 6) to install | f) joint positions |
| 7) to assemble | g) machine vision |
| 8) to drive | h) satellites into the bay |
| 9) to sense | i) any point within a sphere |
| 10) to produce | j) satellites to higher orbits |

VIII. Find synonyms in the following list:

to operate, to generate, to mount, to perform, to look like, to permit, to return, to connect, to work, to sense, to allow, to bring back, to produce, to link, to detect, to install, to resemble, to accomplish.

IX. Complete the sentences using information from the text.

1. The Space Shuttle prime objective is ...
2. Satellites to be deployed are ...

3. Defective satellites are brought back into the bay for...
4. The skeleton of the arm is covered with...
5. The end effector can move to any point along the surface of a sphere due to ...
6. The elbow joint allows the RMS ...
7. The end effector can assume any desired orientation with the help of ...
8. The TV cameras at the wrist and the elbow make it possible ...
9. The machine vision system consists of ...
10. The distance between the end effector and the target is determined by...
11. Having grasped the payload, the end effector is ready...
12. The rotational and translational hand controllers look like ...

X. Paraphrase the following sentences changing the underlined verbs into the Passive form.

1. Once the orbiter is in space, it is necessary to deploy the payloads.
2. The RMS will have to boost the satellites from the cargo bay to higher orbits.
3. Electric actuators drive the manipulator joints.
4. The computer determines the distance the end effector is from the target.
5. There are a lot of tasks the RMS can perform in space.
6. The operator can see the target the arm is moving to on closed-circuit TV.
7. The RMS will have to bring back defective satellites into the cargo bay.
8. The payload the manipulator is to grasp has a grapple fixture.
9. Having grasped the payload, the end effector is ready to deploy it.
10. The cargo bay may contain satellites the RMS will boost to higher orbits.
11. The operator keys the tasks for the RMS to perform into the computer.

XI. Speaking practice.

1. Explain in your own words: ‘The end effector is the most radical departure from the human arm analog.’
2. Determine the number of DOF in the human arm from shoulder to hand. Compare it with that of the RMS. Does the RMS have any improvement on the human arm?
3. Speak about the RMS’s joints and their possible movements (use Fig. 1).
4. Speak about the RMS’s cameras and their functions (use Fig. 1)
5. Describe the process of grasping payloads by the end effector.
6. Try to describe the RMS operation in a fully automated mode.
7. Give a brief summary of the text.

Useful language: the text deals with, the RMS design, the RMS operation, a detailed description of how ..., types of joints, machine vision system, much consideration is given to, end effector design, principle of operation of the end effector.

XII. Look through Text 1B and give the gist (суть) of it in one sentence.

TEXT 1B

ROBOT PRIMER (I)

A typical robot consists of one or more manipulators (arms), end effectors (hands), controller, power supply, and possibly an array of sensors to provide environmental feedback. Because the majority of robots in use today are for industrial purposes, classification of them is based upon their industrial function.

Robot classes

Non-servo robot – the simplest form of robot. This robot picks up an object and places it in another location. Freedom of movement is usually limited to two or three directions. Non-servo robots are capable of point-to-point motions. For each

desired motion, the manipulator moves at full speed until the limits of travel are reached. Non-servo robots are often referred to as “limit sequence”, “bang-bang”, or “pick-and-place”. When non-servo robots reach the end of a particular motion, a mechanical stop or limit switch is tripped, stopping the motion.

Servo robot – robots of several categories that employ servomechanisms for the manipulator and end effector to alter direction in midair without tripping a mechanical switch. Five to seven directions of motion are common, depending on the number of joints in the manipulator. Servo robots are also capable of point-to-point motions but movements of manipulators are accomplished with controlled variable velocities and trajectories. More common are continuous path servo robots which are appropriate when a robot must follow a desired trajectory in a smooth, constant motion. Motions of servo robots are controlled without the use of stops or switches.

Programmable robot – a servo robot that is driven by a programmable controller that memorizes a sequence of movements and repeats these perpetually. This kind of robot is programmed by “walking” the manipulator and end effector through the desired movement.

Computerized robot – a servo robot run by a computer. This kind of robot is programmed by instructions fed into the controller electronically. “Smart” robots, as they are known, may include the ability to improve upon their work instructions.

Sensory robot – a computerized robot with one or more artificial senses to sense its environment and feed back information to the controller. Senses are usually sight or touch.

Assembly robot – a computerized robot, probably with sensors, that is designed for assembly line jobs.

XIII. Try to guess the meaning of the following words from their description:

primer *n* – a small book for teaching children to read; a small introductory book to a subject;

feedback *n* – the return to the input of a part of the output of a machine, system, or process (as for producing changes in an electronic circuit that improve performance or in an automatic control device that provide self-corrective action);
to be referred to as – to be called or named;
sequence *n* – a set of related things that happen or are arranged in a particular order;
appropriate *adj* – suitable or right for a particular situation or purpose;
perpetually *adv* – continually;
to feed *v* – to move smth. into a machine in order to be used or processed.

XIV. Match the word combinations in the left column with those in the right one:

- | | |
|-----------------------------|--|
| 1) servo robot | a) искусственный орган оцувствления |
| 2) non-servo robot | b) робот с сервоуправлением |
| 3) continuous path robot | c) приводить в действие выключатель |
| 4) artificial sense | d) цикловой (перегрузочный) робот |
| 5) limit switch | e) робот с управлением по упорам |
| 6) to trip a switch | f) концевой выключатель |
| 7) pick-and-place robot | g) оцувствленный робот |
| 8) point-to-point movement | h) робот без сервосистемы |
| 9) bang-bang robot | i) робот с контурной системой управления |
| 10) articulated manipulator | j) позиционное движение |
| 11) sensory robot | k) манипулятор шарнирной конструкции |

XV. Translate the following sentences paying attention to the Infinitive complex with ‘for’.

1. The ultimate goal is for the climbing robot to calculate its own best path up a cliff.

2. There are more advanced systems that allow for the movements and end points to be recorded in an unspecified order.

3. Cost-effective manipulators are a key technology for service robotics to roll forward.

4. There are as many different types of robots as there are tasks for them to perform.

XVI. Translate Text 1B.

XVII. Answer the questions.

1. What criterion is used for the robot classification given in the text?

2. What devices are used to control the motion of non-servo robots?

3. What is the difference between a servo and non-servo robot?

4. What are other names for a non-servo robot?

5. What are the most common “senses” of a sensory robot?

6. What kind of robots are called “smart” and why?

7. How can robots be programmed?

XVIII. Give a brief summary of the text.

Useful language: the text is intended for, the elementary knowledge of robotics, to be based on (upon), to provide feedback, to alter direction, to be driven by, to be referred to as, to trip a switch, to follow a trajectory, to feed information into the controller.

XIX. Discussion point: Are there any other classifications of robots you know? What criteria can be used for robot classification?

Useful language: to be based on (upon), to be divided into, to be grouped according to (by), to fall in a category, to differ from, to be applied to, to feature.

XX. Fill in the gaps with appropriate derivatives (forms) of the words given in capital letters. The first gap is filled as an example.

A robot may be defined as a self-controlled device *consisting* of electronic, _____, or mechanical units.

More _____, it is a machine that functions in place of a _____ agent.

Robots are especially _____ for certain work functions because, _____ humans, they never get tired; they can endure physical conditions that are _____ or even _____; they can operate in airless conditions; they do not get bored by repetition; and they cannot be distracted from the task at hand. Thus, robots are especially _____ for space _____. Not only can they travel to environments too hostile or too _____ for human _____, but they can also enhance the work schedule of a _____ space mission.

CONSIST
ELECTRICITY
GENERAL
LIVE
DESIRE
LIKE
COMFORT
DANGER
VALUE
EXPLORE
DISTANCE
EXPLORE
MAN

UNIT 2

I. Word list:

altitude *n* – высота

assume *v* – принимать, брать на себя

attitude *n* – пространственное положение, ориентация (ЛА)

cease *v* – останавливать, прекращать

decay *n* – спад; ослабление; *зд.* снижение

delay *n* – задержка

exhaust *v* – израсходовать, использовать полностью

fail *v* – *зд.* разрушаться, выходить из строя

gain *v* – получать, приобретать

inherent *adj* – неотъемлемый, присущий, свойственный

insurmountable *adj* – непреодолимый

jaw *n* – *зд.* захват, зажим

plier *n* – щипцы, кусачки, плоскогубцы

regardless of *adv* – независимо от, не взирая на

relatively *adv* – относительно, сравнительно

relay *n* – *зд.* радиорелейная линия

retrieve *v* – возвращать, восстанавливать

rendezvous *v* – *зд.* сближаться, стыковаться

route *v* – направлять

sense *n* – *зд.* смысл

sound *adj* – правильный, здравый, логичный

stow *v* – укладывать, складывать

tie *v* – связывать, прикреплять

transfer *n* – перемещение, перевозка, перегрузка

transponder *n* – транспондер, преобразователь непрерывных данных в цифровые

ultimately *adv* – в конце концов

wear out (wore, worn) *v* – изнашивать(ся)

II. Translate the following word-combinations:

Remote Orbital Servicing System, attitude control gas, orbital transfer vehicle, relatively low-cost alternative satellite servicing system, robot spacecraft, servicing period to follow, worn-out modules, one to two second time delay, plier-like jaws, specific mission requirements;

to experience orbital decay, to make sense, to assume teleoperated control, to produce stereo pictures on the monitor, to remove defective modules, to be similar in appearance, to result in smth, to result from smth.

III. Translate the sentences keeping in mind that “with” is translated differently depending on the context.

1. With the metric system, everything is measured in terms of three standard units: the meter, the kilogram and the second.

2. With simple sensors installed on the end-of-arm tooling (рабочие органы), a robot can remove parts and materials from stacks, one piece at a time.

3. An industrial robot which is equipped with a welding head (сварочная головка) is also practical.

4. The cost advantage of hydraulic actuators diminishes with decreasing size.

5. Smarter and smarter machines should eventually be able to respond to many events and circumstances with appropriate responses that make them seem intelligent.

6. Regardless of a robot’s design or tasks, there are still some issues with its mobility.

7. With wireless technologies now practical and available, creating intelligent robots is a novel area for research and investigation.

8. With advances in microchip design, nanotech sciences, software architecture and minipower cells, robot systems can be more than just another pair of eyes.

IV. Read and translate Text 2A.

TEXT 2A

REMOTE ORBITAL SERVICING SYSTEM

One of the objectives of the Space Shuttle is its ability to serve as a platform for repairs and servicing of orbital payloads. Eventually, all artificial Earth satellites fail, regardless of how well they are designed and constructed. Attitude control gas becomes exhausted, electronic and mechanical components cease to function, and satellites ultimately experience orbital decay and reenter the atmosphere. Considering the high cost of building satellites and launching them, sometimes in the hundreds of millions of dollars, gaining the longest term use of them makes sound economic sense.

Because the Space Shuttle's orbit is restricted to a maximum altitude of approximately 1100 kilometers, only satellites in orbits below that altitude can be rendezvoused with directly by the Shuttle Orbiter for servicing. Higher orbiting satellites have to be retrieved with some sort of orbital transfer vehicle and brought back to the Orbiter for servicing in the cargo bay. If needed work is too extensive, the satellite may be stowed for return to Earth and relaunch at another time. Because of inherent dangers in sending space-suited astronauts into the cargo bay for servicing operations and because of the cost and complexity of bringing satellites down to the Shuttle's orbit and later reboosting them, NASA scientists and engineers are studying a robotic system as a relatively low-cost alternative satellite servicing system. The concept is called Remote Orbital Servicing System or ROSS. With this system, human operators would be able to sit in a control room on Earth and direct a robot spacecraft to perform the needed servicing and repair tasks on a satellite.

The ROSS spacecraft would be launched into space by the Space Shuttle. Once deployed from the Shuttle's cargo bay, an operator on Earth would assume teleoperated control of ROSS.

This would free the Orbiter and its crew for other tasks. With a built-in booster system, ROSS would be directed to rendezvous with a particular satellite. In the servicing period to follow, worn out or defective modules on the satellite are removed with two manipulator arms and replaced.

To enable the teleoperator to view the progress of the servicing operation, six television cameras are mounted on and around the manipulator arms. Two of the cameras are tied together like human eyes to produce stereo pictures on the teleoperator's monitor on Earth. One camera is mounted on each manipulator arm for detailed observation and for observation in places not visible to the other cameras. A fifth camera is placed some distance from the stereo cameras and a sixth camera can be placed in a variety of locations depending upon specific mission requirements.

The manipulators of ROSS are quite similar in appearance to the RMS of the Orbiter. These manipulators, however, are only 2.8 meters long and the end effectors feature plier-like jaws for grasping rather than the RMS wire snare. Both manipulators are jointed like the RMS and feature six degrees of freedom.

In the basic ROSS concept, control of the spacecraft would be accomplished directly by the human operator on Earth. Communications between the spacecraft and Earth would be routed through communications satellite relay, resulting in a one to two second time delay. In experimentation, delays of this length caused no insurmountable control problems. As robotic technologies advance, ROSS will be able to take over more of the servicing functions on its own with only supervisory control from the ground. Eventually, it should become possible for the human controller to direct an advanced ROSS with commands such as "Pull transponder R6, test it, and replace if necessary." Such a command would trigger ROSS's memory to follow dozens of operations automatically.

V. Answer the questions.

1. What happens with artificial satellites with time?
2. Why is it so important to use satellites for the longest possible term?
3. Where are defective satellites normally repaired?
4. What are orbital transfer vehicles needed for?
5. What is the reason for designing an alternative satellite servicing system?
6. What is the advantage of teleoperated control from the ground?
7. What is the function of a built-in booster system?
8. How many manipulators will be used in ROSS and what tasks will they perform?
9. What are the cameras on the ROSS manipulator for?
10. How are stereo pictures produced on the teleoperator's display on Earth?
11. What are the differences between the RMS and the ROSS manipulator?

VI. Say if the following is true or false and change the false statements into true ones.

1. Orbital transfer vehicles are needed to bring satellites in orbits below 1100 km back to the Space Shuttle.
2. It is absolutely safe to send astronauts into the cargo bay for servicing operations.
3. ROSS would be launched into space from the Earth.
4. ROSS would be controlled directly by the astronauts from the Space Shuttle.
5. ROSS will function in a fully automatic mode.
6. In experimentation, there were serious control problems with ROSS due to communication delays.

VII. Find in the text all the words that can be used as different parts of speech. For instance, the words ‘service’ and ‘repair’ can both serve as a noun and a verb. See, who of you will find more words like these. Note, that there are more than 20 of them. Use some of the words in sentences of your own.

VIII. Paraphrase the following without using the underlined parts of the sentences. Use the prompts in brackets.

Example. The Space Shuttle has the ability to serve as a platform for repairs and servicing of orbital payloads. (can) – The Space Shuttle can serve as a platform for repairs and servicing...

1. All artificial satellites ultimately experience orbital decay. (move)
2. The teleoperator will view the progress of the servicing operation. (how)
3. Using the communication satellites relay resulted in a one to two second time delay. (cause)
4. Delays of this length caused no insurmountable control problems. (result from)
5. As robotic technologies advance, ROSS will be able to take over more of the servicing functions on its own. (with, perform, in the automatic mode)
6. Eventually, it should become possible for the human controller to direct an advanced ROSS with verbal commands. (be able to)
7. Considering the high cost of building satellites and launching them, gaining the longest term use of satellites makes sound economic sense. (as, using, is)

IX. Complete the sentences using information from the text.

1. It is economically reasonable to use satellites as long as possible because ...
2. The Space Shuttle can only rendezvous with the satellites which ...

3. Now that ROSS hasn't been created yet there are 2 variants of satellite servicing: they can be serviced by 1) ... and 2) ...

4. Satellites are returned to Earth for servicing if ...

5. ROSS would be a safe alternative to ...

6. ROSS is supposed to become a low-cost alternative to ...

7. Six TV cameras are mounted on the manipulator arms for ...

8. The human operator on Earth would communicate with ROSS via ...

X. Make up a plan and give a brief summary of Text 2A.

Useful language: the article gives a detailed description of, the system is designed (for, to do smth), to perform servicing and repair tasks, to serve as an alternative to, to deploy the system, to assume teleoperated control, to be equipped with TV cameras, much consideration is given to, communication between the spacecraft and the Earth, in conclusion, to operate automatically, to control the system with verbal commands.

XI. Read Text 2B and find answers to the questions.

1. What is the relationship between the number of DOF and the number of joints in the manipulator?

2. What kind of actuator would be preferable for a low-powered manipulator?

3. What is the most common kind of end effector?

TEXT 2B

ROBOT PRIMER (II)

Manipulator arm configurations

To accomplish robotic motions, four basic configurations of manipulator arms have been devised. These include rectangular, cylindrical, spherical, and anthropomorphic (articulated or jointed arm). Each design features two or more degrees of freedom (DOF). DOF refers to each direction an arm is capable

of moving. A simple linear or straight line movement is one DOF. To follow a two-dimensional curved path requires two DOF both up and down and right and left. More complicated motions require many degrees of freedom. To locate an end effector at any point and orient the effector in a particular work volume requires 6 DOF. More degrees might be required if the manipulator has to avoid other equipment or obstacles in performing its tasks. For each DOF, the joint, rotary or linear, is required. To increase the versatility of the manipulator arm design, two or more of the four basic configurations can be combined on the same manipulator.

Actuators¹ (Power supply)

Moving the manipulator joints is accomplished by actuators. The three main forms of actuators in use today include pneumatic, hydraulic, and electrical. Pneumatic actuators use pressurized gas to move the joint. Gas is propelled by a pump through a tube to a particular joint and actuates movement. Air brakes on diesel trucks are a common form of pneumatic actuator. Pneumatic actuators are inexpensive and simple but their movement is “squooshy”² and consequently they are usually reserved for “pick-and-place” robots.

Hydraulic actuators are the most common industrial system and are capable of producing high power. The principle disadvantages of hydraulic actuators are the accompanying paraphernalia³, including pumps and storage tanks, and problems with system leaks.

Electric actuators offer clean movements, can be precisely controlled, and are very reliable and accurate but do not deliver the high power-to-system weight ratios that hydraulic actuators can deliver. For small actuator functions, electrical actuators are preferred because the cost advantage of hydraulic actuator diminishes with decreasing size.

End effectors

The “hand” or gripping device is usually attached to the end of the robot’s manipulator. The functions of the end effector

include grasping, pushing and pulling, twisting, using tools, and performing insertions⁴ and assembly. End effectors can be mechanical, vacuum or magnetically operated, a snare device⁵, or have some exotic configuration. The design of an end effector is determined by the shapes of objects it has to grasp. Most end effectors are simply some gripping or clamping devices.

¹ actuator – исполнительный механизм, привод.

² squooshy *infm* – вязкий (инерционный).

³ paraphernalia *n* – атрибуты, принадлежности.

⁴ insertion *n* – установка, монтаж (компонентов).

⁵ snare device – устройство в виде петли.

XIII. Translate Text 2B.

XIV. Translate into English and ask your partner the following questions.

1. Сколько степеней свободы необходимо манипулятору, чтобы поместить рабочий орган в любую точку рабочей области?
2. Как можно увеличить подвижность манипулятора?
3. Какой привод манипулятора наиболее широко используется?
4. Каковы достоинства и недостатки этого привода?
5. Какие достоинства и недостатки имеет электрический привод?
6. От чего зависит конструкция рабочего органа?

XV. Complete the sentences by choosing the right option. Mind that there can be more than one of them.

1. Manipulator arm configuration can be

- | | |
|---------------|--------------------------|
| a) pneumatic | c) rectangular |
| b) mechanical | d) magnetically operated |

2. Actuators can be

- | | |
|----------------|----------------|
| a) cylindrical | c) articulated |
| b) electrical | d) hydraulic |

3. End effectors can be

- a) spherical
- b) mechanical
- c) vacuum-operated
- d) anthropomorphic

4. End effectors can

- a) paint
- b) pull
- c) perform insertions
- d) climb

XIII. Render in English one of the parts of Text 2B.

XIV. Read and translate the following text without a dictionary and make up its summary in the written form.

Useful language: the article gives a classification of ... , to be divided into, in turn (в свою очередь), an improvement on the human arm, computer-operated RMS, human-controlled RMS.

TEXT 2C

TYPES OF ROBOTS IN SPACE

Today, two types of devices exist which can be considered space robots. One is the ROV (Remotely Operated Vehicle) and the other is the RMS (Remote Manipulator System).

Typically, ROVs are used in nuclear facilities for inspection and repair in areas too dangerous for humans, and by police bomb squads for removal of potentially hazardous materials. Space researchers are especially interested in this type of robot for terrain exploration in space.

An ROV can be an unmanned spacecraft that remains in flight, a lander that makes contact with an extraterrestrial body and operates from a stationary position, or a rover that can move over terrain once it has landed. It is difficult to say exactly when early spacecraft evolved from simple automations to robot explorers or ROVs. Even the earliest and simplest spacecraft operated with some preprogrammed functions monitored closely from Earth.

The most common type of existing robotic devices is the crane-like RMS, or robot arm, most often used in industry and

manufacturing. This mechanical arm recreates many of the movements of the human arm, having not only side-to-side and up-and-down motion, but also a full 360-degree circular motion at the wrist, which humans do not have. Robot arms are of two types. One is computer-operated and programmed for a specific function. The other requires a human to actually control the strength and movement of the arm to perform the task. To date, a robot arm has performed a number of tasks on several NASA space missions – serving as a grapppler, a remote assembly device, and also as a positioning and anchoring* device for astronauts working in space.

* anchoring – эд. стабилизация.

UNIT 3

I. Word list:

awareness *n* – осведомленность, компетентность

communicate *v* – сообщать, передавать

eliminate *v* – ликвидировать, устранять

EVA (Extra-Vehicular Activity) – внекорабельная деятельность (ВКД)

fatigue *n* – усталость

formidable *adj* – огромный, труднопреодолимый

glove *n* – перчатка

helmet *v* – шлем

latency *n* – время ожидания, задержка

loop *n* – петля, контур, замкнутая система

maintain *v* – *зд.* поддерживать

performance *n* – 1) работа, функционирование; 2) рабочая характеристика, эксплуатационные качества; 3) производительность, эффективность

posture *n* – осанка, поза, положение

satisfy *v* – удовлетворять

scar *n* – шрам

seek *v* – искать, *зд.* стремиться

technique *n* – 1) метод; 2) технология; 3) техническое средство

telepresence *n* – дистанционное (теле) присутствие, эффект присутствия при дистанционном управлении

track *v* – следить, отслеживать

unobtrusive *adj* – ненавязчивый, незаметный

whereby *adv* – при помощи чего, посредством чего

II. Translate the following word combinations:

EVA astronaut, EVA astronaut equivalent, EVA task, robotic target, telepresence control system, remote control, control loop, situation awareness, virtual reality control interface, three-axis hand controllers, higher human performance, master-slave relationship, master-slave control mechanism, helmet mounted display, force feedback, tactile feedback, force and tactile feedback gloves, posture trackers;

to jump generations ahead, to establish remote control, to maintain situation awareness, to visualize the workspace, to handle system latencies, to reduce operator fatigue, to satisfy requirements, to track operator motions, to communicate operator motions to the robot.

III. Translate the sentences paying attention to the Complex Subject.

1. Automated robotic inspection is expected to be an important element to offload time consuming inspection activities from astronauts.

2. As the comet approaches the sun, gases seem to be exploded out of its head to form gigantic tail that points away from the sun and extends millions of miles into space.

3. This method does not appear to offer any advantages for it depends on the production of materials with higher strength to weight ratios.

4. Space rockets are sure to assist in advancing our knowledge of high-energy radiations from outer space.

5. In this experiment, the first robot shot off a message requesting the temperature from the second robot, which happened to be sitting a mile away.

6. It will be quite a while, if it is to happen at all, before a machine can really be said to “understand” in a conscious sense what is going on around it.

7. Robots proved to be useful in medicine as laboratory and hospital robots.

8. Even your pocket calculator could be said to be Artificial Intelligence – 100 years ago no one would have expected a machine to know how to do maths!

IV. Read and translate Text 3A.

TEXT 3A

THE ROBONAUT PROJECT

Robonaut is a humanoid robot designed by the Robot Systems Technology Branch at NASA's Johnson Space Center. The Robonaut project seeks to develop and demonstrate a robotic system that can function as an EVA astronaut equivalent. Robonaut jumps generations ahead by eliminating the robotic scars (e.g., special robotic grapples and targets) and specialized robotic tools of traditional on-orbit robotics. Robonaut is designed to be used for EVA tasks, i.e., those which were not specifically designed for robots. However, it still keeps the human operator in the control loop through its telepresence control system.

Telepresence control system

Robonaut uses several novel techniques for establishing remote control of its subsystems and enabling the human operator to maintain situation awareness.

In the case of the Robonaut project, the human operator must control forty-three individual degrees of freedom. Therefore, it will be critical for operators to have an effective control interface. In particular, the interface must provide support to the operator for visualizing the workspace, and for handling system latencies such as communication delay. In addition, the interface must enable higher human performance while reducing operator

fatigue and stress. One approach which appears to satisfy these requirements is the telepresence/virtual reality control interface.

The use of three axis hand controllers would present a formidable task for the operator. Because Robonaut is anthropomorphic, the logical method of control is one of a master-slave relationship whereby the operator's motions are essentially mimicked by the robot. The operator performs the arm, head and hand motions for the required tasks and a master-slave control mechanism duplicates the same motions in the Robot. The goal of telepresence control is to provide an intuitive, unobtrusive, accurate and low-cost method for tracking operator motions and communicating them to the robotic system. The component technologies used in Robonaut's telepresence system include Helmet Mounted Displays (HMD), force and tactile feedback gloves and posture trackers.

V. Answer the questions.

1. What is the goal of the Robonaut project?
2. Why are robotic grapples and targets called “robotic scars”?
3. What is Robonaut supposed to do in space?
4. Why is it critical for Robonaut operators to have an effective control interface?
5. What is meant by “an effective control interface”?
6. Why would it be difficult for the operator to control Robonaut using three-axis hand controllers?
7. What is the best control method for Robonaut? Why?
8. What is the principle of master-slave control method?
9. What is the essence of telepresence control?
10. Why do you think the telepresence control method is supposed to be low cost?

VI. Find in the text the English equivalents to the following:

робототехнический объект (мишень), контур управления, более высокая работоспособность человека-оператора,

трехосевая ручка управления, взаимодействие типа «ведущий-ведомый», дисплей, встроенный в шлем человека-оператора, силовая обратная связь (обратная связь по усилию), тактильная (осязательная) обратная связь, устройство слежения за положением тела.

VII. Explain in your own words:

humanoid robot; Robonaut jumps generations ahead; EVA astronaut; EVA tasks; to maintain situation awareness; an intuitive, unobtrusive method; force and tactile feedback gloves; posture trackers.

VIII. Match the words from lists A and B to make pairs of synonyms.

A. (1) to design, (2) to function, (3) to be designed (for), (4) through, (5) to maintain, (6) to provide support, (7) to enable, (8) to handle, (9) to reduce, (10) to mimic, (11) to require, (12) accurate.

B. a) to be intended, b) to develop, c) precise, d) to need, e) to diminish, f) to cope with, g) to help, h) to imitate, i) to act, j) to keep up, k) to make possible, l) by means of.

IX. Paraphrase the following sentences from the text using the words in brackets.

1. The Robonaut project *seeks* to develop an EVA astronaut equivalent. (goal)

2. Robonaut still *keeps the human operator in the control loop* ... (to be controlled)

3. Robonaut uses several novel techniques which *enable* the human operator *to maintain situation awareness*. (to make possible, to be informed)

4. The interface must *enable higher human performance*. (more efficient)

X. Paraphrase the following sentences using the Complex Subject construction with the verbs given in brackets:

Example. CAD/CAM* methods *are widely used* in robotics.
(to know) – CAD/CAM methods are known to be widely used in robotics.

1. The Robonaut *jumps* generations ahead in on-orbit robotics. (to claim (утверждать))
2. This robotic system *will find* a wide range of applications as it conforms to the needs of various workplaces, including nuclear power stations. (to be likely)
3. Robot *performs* just as well on the 100th occasion as it did on the first. (to be sure)
4. A humanoid robot *is* the most appropriate type of robot for EVA applications. (to seem)
5. In the course of experiments robots *produced* superior results to humans. (to find)
6. Since many Space Station servicing tasks will be performed EVA, Robonaut *will be* in great demand. (to expect)
7. The control interface has to be simple, intuitive and efficient, characteristics which *are* unfortunately mutually exclusive in all but the simplest cases. (to have proven)

XI. Translate from Russian into English.

1. Предполагается, что Робонавт будет работать в открытом космосе.
2. Технология «телеприсутствия» позволяет оператору быть в курсе ситуации.
3. Использование эффективного механизма управления несомненно уменьшит усталость и напряжение оператора.

* CAD (Computer-Aided Design) – автоматизированное проектирование.
CAM (Computer-Aided Manufacturing) – автоматизированное производство.

4. Управляющий интерфейс типа «телеприсутствия» основан на управляющем механизме «ведущий – ведомый».

5. По-видимому, метод управления, основанный на технологии «телеприсутствия», удовлетворяет всем описанным выше требованиям.

6. Если бы оператор использовал трехосные ручки управления, его работоспособность была бы намного хуже.

7. Управление, основанное на технологии «телеприсутствия», обеспечивает слежение за движениями оператора и их передачу в робототехническую систему.

8. Для установления дистанционного управления необходим ряд новых технологий.

9. Если бы Робонавт не был антропоморфным роботом, управляющий механизм типа «ведущий – ведомый» был бы не эффективен.

10. Система телеприсутствия Робонавта включает несколько новых технических средств.

XII. Give a brief summary of the text.

Useful language: the article is a presentation of, to jump generations ahead, to function as an EVA astronaut equivalent, much consideration is given to, master-slave control mechanism, to satisfy the requirements, telepresence control interface, to track operator motions and communicate them to Robonaut.

XIII. Read and translate Text 3B.

TEXT 3B

TELEPRESENCE CONTROL SYSTEM

Telepresence uses virtual reality display technology to visually immerse the operator in the robot's workspace. This way the teleoperator feels as if he or she were in the place of the robot. Visual feedback is provided by a stereo display helmet and includes live video from Robonaut's head cameras. The HMD provides a view into the robot's environment, facilitating

intuitive operation and natural interaction with the work site. To be an effective tool for the Robonaut project, the HMD must take into account image registration¹ (stereo or bi-ocular view), field-of-view (FOV), graphical overlay capabilities² and speech recognition capabilities.

Controlling Robonaut's highly dexterous³ fingers and hands is made possible by mapping⁴ the motions of the teleoperator's fingers onto the hand and finger motions of Robonaut. Finger tracking is accomplished through glove based finger pose trackers. Complex manipulation tasks are then made as intuitive as performing the task with your own hands.

Force sensors are built into Robonaut's hands. The forces imparted on Robonaut's fingers can be displayed to the teleoperator by means of a mechanical exoskeleton⁵ worn by the teleoperator. The finger forces measured by Robonaut's force sensors are used to convey haptic⁶ information back to the teleoperator.

Arm, torso and head tracking is accomplished with the use of magnetic based position and orientation trackers. Mapping the motions of the human appendages⁷ to the motions of Robonaut's arms and head is accomplished similarly to the way the finger tracking is performed. The telepresence system will generate robot position commands through teleoperator pose tracking. Future telepresence control will address new methods and algorithms that will significantly improve safety and performance of teleoperated human-scaled dexterous robots during in-space operations.

Developing dedicated⁸ software tools for real-time, camera based, human posture tracking and text and graphical capabilities will achieve this goal for robot operators. These features will allow the natural and unencumbered⁹ control of anthropomorphic robots, while minimizing training and maximizing robot performance. These new technologies seem to have the

potential to provide any telepresence interface with real-time operator tracking and audio-visual feedback. Operators of dexterous space robots will take full advantage of the robots' high performance only if teleoperation is made easy and safe.

¹ image registration – прием изображения.

² graphical overlay capabilities – возможности накладной графики.

³ dexterous – гибкий, ловкий.

⁴ to map – отображать.

⁵ exoskeleton – экзоскелет (робот, надеваемый на человека).

⁶ haptic – тактильный, осязательный.

⁷ appendage – конечность.

⁸ dedicated – специальный.

⁹ unencumbered – без ограничений.

XIV. Answer the questions.

1. What makes the operator feel as if he were in the place of the robot?
2. How are Robonaut's fingers controlled?
3. How does the force feedback work?
4. How are the robot position commands generated?
5. How can safety and performance of teleoperated robots be improved?

XV. Say if the following is true or false.

1. The Robonaut telepresence system includes 1) virtual reality display technology and 2) finger, arm, torso and head tracking technology.
2. Visual feedback is provided by HMD and Robonaut's head cameras.
3. Virtual reality is achieved due to the mechanical exoskeleton.
4. The telepresence system maps the motions of the teleoperator's fingers, arms, torso and head into the corresponding motions of Robonaut.
5. The operator wears a mechanical exoskeleton to look like a robot.

6. Robonaut's finger force sensors provide force and tactile feedback.

7. Head tracking differs from finger tracking.

8. Robot position commands are generated by the teleoperator pose tracking system.

9. The existing technologies are sure to provide safety and high performance of Robonaut.

XVI. Give a brief summary of Text 3B.

Useful language: the article explains the principle of operation of, virtual reality, visual feedback, to take into account, to map the motions of ... into the motions of, finger tracking, force sensors, force feedback, position and orientation trackers, to generate robot position commands, to address new methods and algorithms, to improve safety and performance.

XVII. Read and translate Text 3C. Think of a suitable title to it.

TEXT 3C

Imagine you are sitting at a console remotely controlling a robot with a hand controller. Your job as a robot operator is to insert or extract an electronic box from a rack. The console has multiple CRT¹ screens, each with a different camera view. Additional views may be multiplexed onto these screens by pressing the appropriate buttons. Sometimes the available camera views are inadequate and the cameras must be repositioned by another set of hand controllers. You move slowly and cautiously, fearing that a wrong move may cause permanent damage to the robot, or to the surrounding equipment.

The above scenario basically characterizes telerobotic operations today. Tasks such as this may seem simple to humans, but they are rather difficult for robots designed with "cock-pit"² style operator interfaces. One reason for this

difficulty is that this type of interface can overload the operator's visual and manual capacities. Consequently, the operator may suffer from fatigue and decreased levels of productivity. Another reason for the difficulty is that the mapping of human body movements to the robot is not intuitive. Teleoperation schemes that are counter-intuitive will impede the flow of skills from the human operator to the robot.

The Dexterous Anthropomorphic Robotic Testbed³ (DART) is designed, as a baseline, to operate under a more immersive brand of teleoperation known as telepresence control. DART is shown here operating a tether hook that astronauts use to secure themselves during space walks.

¹ CRT – Cathode-Ray Tube.

² cockpit – партер; кабина самолета, сиденье пилота (в гоночной машине).

³ testbed – испытательная модель.

XVIII. Answer the questions.

1. What are the disadvantages of teleoperation with the use of hand controllers?
2. What is the main advantage of telepresence control as compared to remote control?

XIX. Speaking practice.

1. Explain the phrase “a more immersive brand of teleoperation”.
2. Explain the phrase “a cockpit style operator interface”.
3. Render Text 3C on behalf of the remote teleoperator.
4. How would you act if you were to perform the same task as a telepresence control operator? What would you wear? What devices would you use? What would you see and feel? How would you move?
5. Work in pairs. Imagine that you are designing a humanoid robot and choosing the type of control mechanism. One of you

is sure that the best control method is teleoperation with hand controllers, the other is in favor of telepresence control. Think of the arguments to convince your counterpart that your choice is preferable.

Useful language: to set the problem, to consider the scope of work, to take into account, in my opinion, from the engineering standpoint, cost-effective, considering the high cost involved, a familiar and easy method, to afford smth, to design new technologies, to be worth doing smth, to be short of time or money, an intuitive and unobtrusive control, a more promising type of control, to suffer from fatigue, to result in, decreased levels of productivity.

XX. Read the following words and their derivatives and say what parts of speech they belong to. Use them to fill in the gaps. Mind that not all the words are used in the sentences:

- a) perform – performance – performer;
- b) move – movement – movable – moveless – mover – movies;
- c) manipulate – manipulator – manipulation;
- d) vary – various – variable – variety – variant – variability – variation;
- e) apply – application – applicator – appliance – applied – applicant – applicable;
- f) define – definition – definable – definite;
- g) associate – association – associated;
- h) differ – different – difference – differential – differentiate – differentiation – differently;
- i) locate – location – local – locality.

1. An industrial robot is a reprogrammable, multifunctional _____ designed _____ materials, parts, tools, or specialized devices through variable programmed motions for the performance of a _____ of tasks. (use a, b, c, d)

2. The joints are the _____ components of the robot that cause relative _____ between adjacent links. (use b)
3. The most widely accepted _____ of an industrial robot is one developed by the Robotic Industries _____. (use f, g)
4. Each of the configurations provides a _____ work envelope and is suited for different types of _____. (use e, h)
5. The wrist is used to orient the parts or tools at the work _____. (use i)
6. The robot takes an appropriate action _____ in its memory with the message sent by the operator. (use g)

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